Animal Physiology
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Lecture – 32

Welcome back to the lectures on NPTEL on animal physiology. Today, we will be initiating the section 5, which is essentially the renal system or you can call it kidneys and the regulation of body fluids or excretory system. We have talked about the way the blood from the heart is being pumped, and the impure blood goes to the lungs, where it gets the essential oxygen, which it lacks after supplying the whole body. The oxygenated blood from the heart goes to lungs, gets oxygenated, comes back, and then it is being pumped all over the body. This is one mode of clearing up the blood. There is another mode where basically you have to get rid of the other salts, which are present in it, which body does not need like, urea and many other salts are there, which has to be got rid of. You have to maintain the exact osmolarity, osmolality, PH, and all these things of the blood, which is taken care. The biggest junk of this purification takes place in the kidneys.

Essentially, what exactly happens here is, that all the blood; they go into the kidney. There is a kind of a very well developed filtration assembly, where the blood gets filtered out of all the unwanted things, and the filtered blood moves back to the body. Whereas, all the unfiltered agents which are being rejected by the blood, while it pass through the mesh or the sieves, just like filter. It passes through and whatsoever has to be rejected and it is selectively rejected. Whenever you see a sieve, say for example, you have a pot of a tea. So, when you pass through it, all the tea leaves get trapped so, that is, these are kind of sieves, which are not like non-selective things.

You cannot decide whether the smaller leaves, based on the size of the filter; things which are bigger than that will stay there; things which are smaller than that will pass through it. But here, when the nature has designed the sewing mechanism, it is much more; I should say a very smart material or much more, like a very programmed thing. Based on this, there are different transporters, which pull it out through the sieves. It is much more, I should say much more versatile as compared to a physical sieve, whenever you think of.

So, it passes through the sieve and unwanted things are being thrown out. Then the blood goes back. Those unwanted things along with certain amount of water, is being excreted out from your body in the form of urine. Here, there are few things which has to be kept in mind. This whole process has to be very tightly regulated, because you cannot afford to lose a lot of water, in that whole process. Because, when you are pulling out some of the electrolytes, which body does not need or some of the smaller molecules like, urea and all these things; you have to ensure that in that process of clearing up, we should not lose sufficient water, that we start suffering from dehydration, or other physiological problem or the homoeostasis goes on the wrong direction, or the PH changes significantly. So, all these things are very tightly regulated.

In order to understand this, in this section, what we will essentially do is we will first in this class, we will talk about the anatomy of the sieve or anatomy of the kidney. This is the first thing we will do today; the individual elements of the kidney which are responsible for this function. Then, we will move on to the part 2, where we will be talking about the exact mechanism; osmosis, reverse osmosis and all those mechanisms, which regulate this clearing up process.

Then the third part of this segment, we will be talking about different control mechanisms, which regulate this process, and simultaneously, we will be talking about, if there is a misregulation; what is really meant by kidney failure? What is meant by dehydrating condition, when the water is being lost? How in (( )) system comes into play?. So, that will be the third part of this particular segment, what we will be dealing with. Today, let us start with to give you an overall topology, maphology and anatomy of the kidney, because that will go all along in your understanding; how really the blood is getting into the kidney and how it is getting cleared off filtered and everything. So, let us start with the anatomy of kidney.

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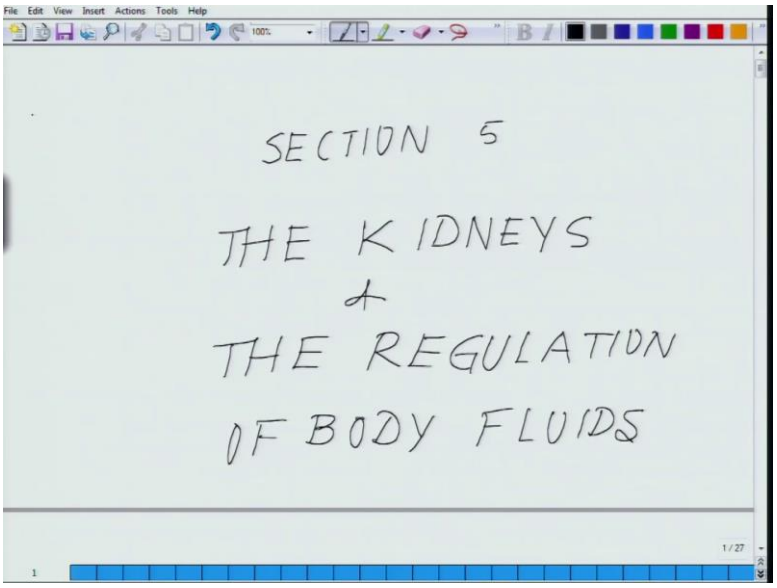

We are into section 5; the kidneys and the body fluids, and the regulation of body fluid. Now, most of you have seen kind of, at some point or other, the structure of the kidney. Here, I will just draw it.

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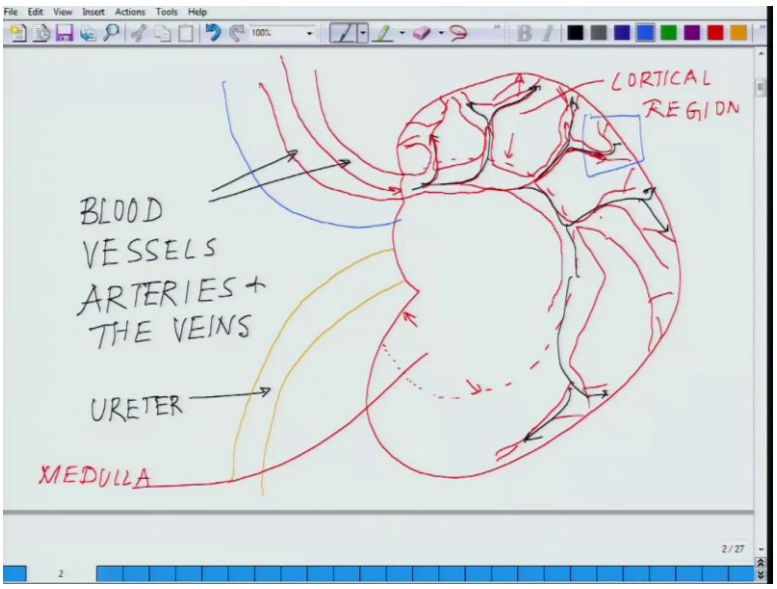

It looks something like this. It is a bean shaped organ, (( )) the abdominal, lower in the abdominal part of your body and there are blood vessels coming in, sorry. There are two kinds of blood vessels that come in the venous and arterial blood, see likewise. Then, there is another organ which is called ureter. These are taking the blood away towards

the heart and this is called ureter. These are the blood vessels which are entering or exiting arteries in the veins. You have two kidneys and the veins.

Now, inside this, is interesting how the blood vessels. This part is divided into like, two segments; one is called the medulla; the other one is called cortex. The cortical region is from here to here; this is called the cortical region of the kidney or cortex of the kidney, whereas, the inner part is called the medulla. Now, when the blood vessels enters, this is very interesting the way, they distribute it like this; this geometry is very essential for you people to understand, because this geometry really helps in the whole clearing up process. There are these creatures coming in between, just keeping the, likewise, like this. It is almost like a tree like structure by which, it is completely getting spreading out all over the place, likewise.

Now, what is happening is that, blood is traveling. You just missed up on the other blood vessels in something like this, just forget about it. Now, here it is the blood entering and then, the blood is moving all along these channels; all over the place, likewise. It all spread out there. All the finer branching or all taking place at the far end of the cortical regions, likewise and so forth. At this cortical region, what you essentially have something, say, if I had to blow off this image; this part onto the next slide.

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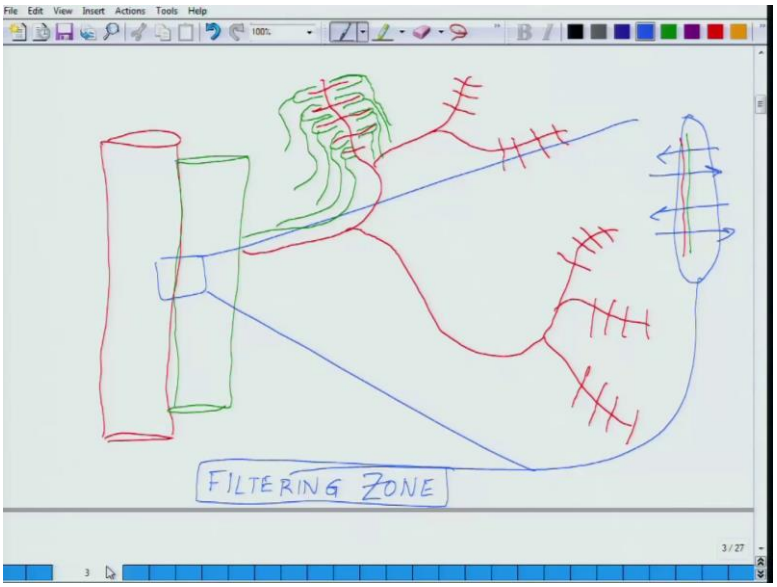

I am going to blow up this image in the cortical region. It is something like this, one second. This is at the cortical region, how this is all getting spread. Near the branching of

the blood vessels like this, at the cortical region, likewise, there is a lot of finite branching. Along this finite branching, lies your very adjacent to them, lies a set of tubular structure like this. These are the individual tubular structures, something like this. And this tubular structure, what I am drawing in green, what you are seeing now; these tubular structures are the structures, which are essentially responsible; these are the sieves elements or these are the filter elements, and those are called nephrons. So, all along, you will see 1000s and 1000s of such nephron structures. What is happening? If this is the blood vessel, there is a zone where the blood vessel is under, is kind of covered by like, those who have seen a distillation assembly, you might remember. There is a coiling. There are certain zones where the blood fine capillaries are being coiled around by these nephrons.

What is happening to the blood is that, there are two tubes, likewise. If this is the blood vessel, if this hand, what I am showing you now is my blood vessel, the blood is bringing very close to it, in close alignment. This is the other hand; it is in close alignment, which is sitting like this. It is at these zones, where they are in physical contact, mind it, they are not connected tubes; they are two separate tubes like this; they are two tubes, something like this, like, let me draw it that will make more sense. It is something like, if I had to draw section, it is like this. If this is the blood vessel then it is in close proximity, you have these vessels going. But, they are two separate entities. So, if I blow up this part, it will be something like this. Here, you will be able to physically see two independent walls. It is this zone, this critical zone, where all the different kinds of exchange processes are taking place. So, this is the zone of filtering zone.

This is the filtering zone and this is very interesting to understand, what is the architecture of the other tube, which I was drawing in green. The reason why, I am highlighting on this part is this, because unless this particular aspect is clear, that how this whole topography is being maintained, it is really tough to understand, how the kidney really function. If I go back to this particular drawing, I can further, you will see. In a text book whenever, you will see, you will see something like this.

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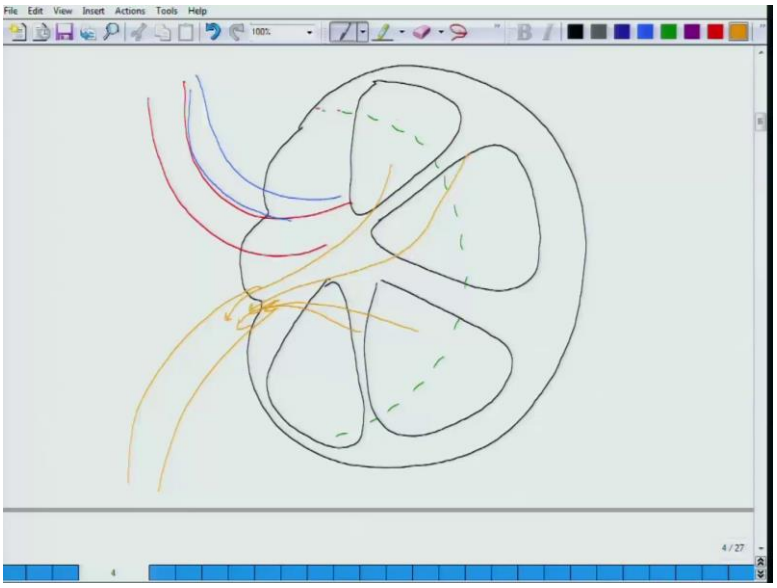

The structure of the kidney, in a text book will be shown like this. On this, you will find structures like this. You might have come across in class 7 or 8 or somewhere, this kind of structure. Here, the blood vessels are entering into the kidney. Here, are another series of blood vessels which are entering into the kidney and here, the ureter is coming.

Essentially, I told you that, this is the cortical region and the medullar region. All those, what is being collected from here, during this whole filtration process; I showed you. They are all eventually dumped onto this, from all over the place, by those vessels of what I called as the nephrons. Those filtration assemblies are called nephron, which are in close proximity within the blood vessel. Essentially, the physical difference between, whenever we talk about sewing or filtering is, that whenever we talk about filter; from a tube, we pour the whole fluid and it passes through a filter and goes through. But here, no such thing is happening. Still the blood is not kind of, anything out into any cavity or anything.

It is remaining in a tube and is surrounded by another tube in close proximity. There are some osmotic phenomenon which is taking place; reverse osmosis, osmosis diffusion, likewise. There is two or three phenomenon, by which the salutes are getting moved from one side of the tube to the other side of the tube; that is what constitutes the whole filtration. With this overall understanding of it, what I will do, I will move on the

structure of those smallest component or those sewing elements, which is the key for this particular class. Let us talk about the anatomy of those.

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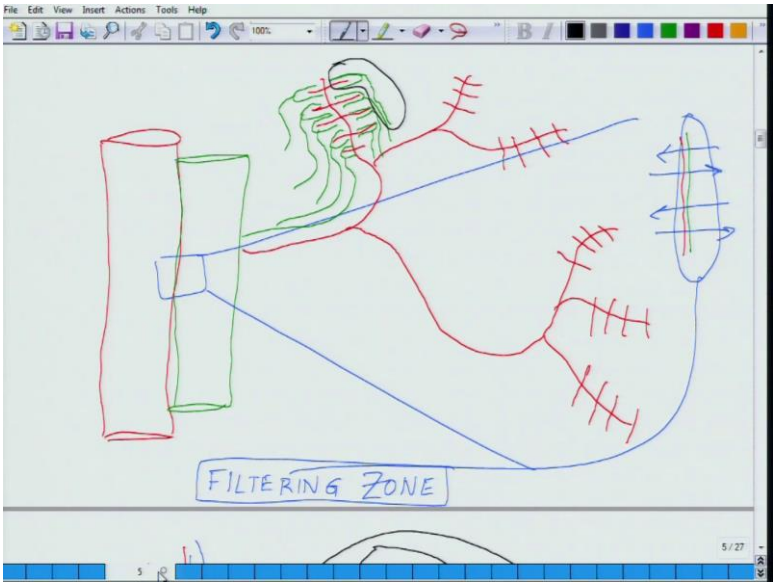

Essentially, what we are talking about, now, we are dealing with the anatomy of these individual elements. The anatomy of the individual element is something like this. This whenever, you go through any text book, it is a very complex structure. I will try to simplify the structure as much as possible, because this is the very key to our understanding.

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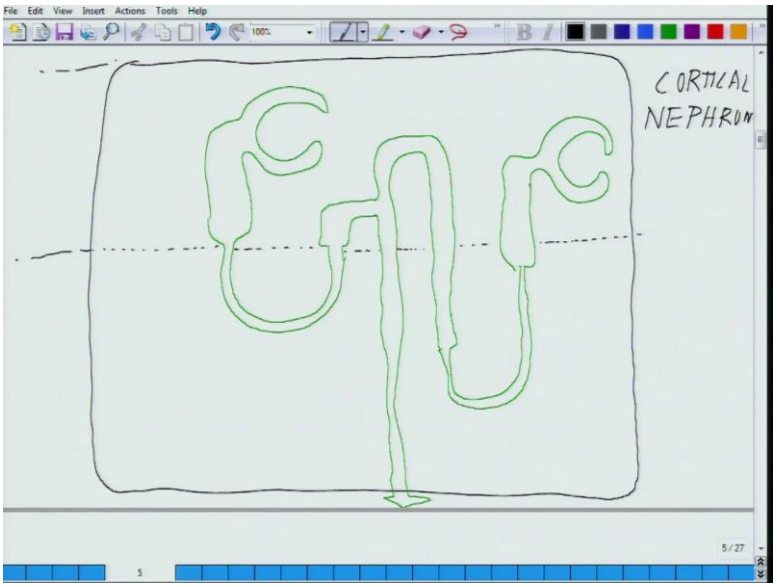

Now, we are considering these as cortical nephrons. There are couple of terms, you will get; cortical nephrons, medullary nephrons. So, basically what does that mean is that those nephrons, which are lying in the cortical region; there are nephrons which lies in the medullary region also.

If they are lying in the cortical region, they are called cortical nephrons, but if they lie in the medullary region, they are called medullary nephron. But if there are nephrons, which are part of the body, lies in the cortical region; part of it lies in the medullary region. Coming back and this is what I will be drawing is essentially, your cortical nephron. So, the structure is something like this. I will take time, because this structure is very critical, and one has to understand this structure nicely, before one understands, what is happening in the kidney. You see, this is a very convoluted tube. It is a kind of changing shape and size and all other things. Now, what I will do; let me just. The reason for this line, is part of it, which is, this is the part I was showing in the drawing. If you go back to the slide, this one.

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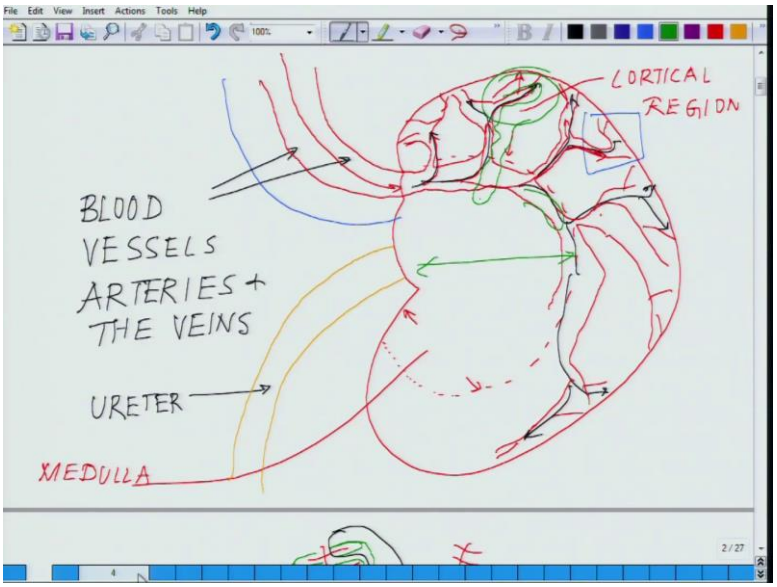

If this is, I told you, this is the medullary region. This part is the medullary region and these nephrons are lying all over it, likewise. So, part of their body lies in the medullary region, and part of it lies in the cortical region; this is very interesting. When the major filtration assembly is lying in the cortical region, it is called cortical nephron. When the

major filtration body is lying in the medullary region, it is called medullary nephron. What we will do in this picture, we will, this is this part is the cortical region; cortex.

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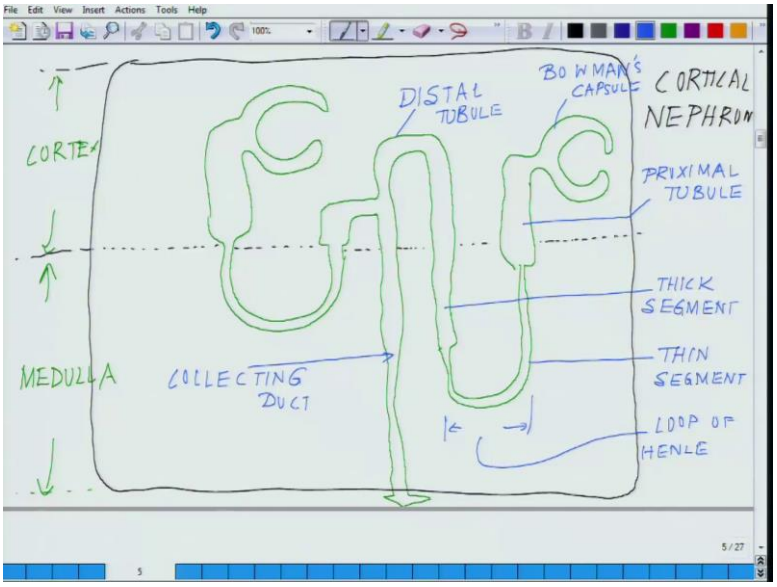

This part, where it gets extended is called medulla, where the tube is kind of descending down. So, this region is called the distal tubule. This is called the Bowman's capsule. This part is called the proximal tubule, and this one is called the thick segment. This one is called the thin segment, and there are significance for these different thin segments and thick segments. This loop, what you see the looping thing technique, this is called loop of Henle, one second, like this. This one is called the collecting duct, I showed you that, fine.

If you look at the structure, it has a kind of very tubular structure, like this. It moves like this; it moves like this. It is a very convoluted tubular structure, and this is what, all along the blood vessel, it runs very parallel to blood vessels. If I had to introduce the blood vessels, this already is a complex structure with the loop of Henle and the collecting duct. These collecting ducts, essentially, what is happening? I told you that all these, the way the urine formation is taking place is, one second, this is the one.

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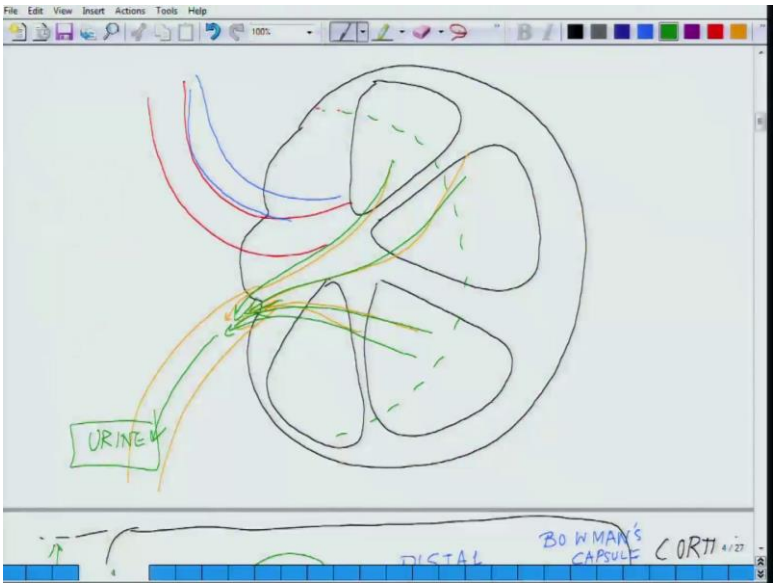

All the collecting ducts, which I just now drew, all these collecting ducts are draining out to the ureter, and which is nothing, but your urine. In other word, whenever we talk about that there is a kidney failure, which essentially means your nephronal structure is getting damaged for some reason or other. If you look at the nephron structure very carefully, you will see that there are zones, where the segment is thick; there are zones where segment is thin. As we will move further, you will see, what are the functional significance of these different kinds of thick segment, thin segment, and there are specific zones, where a specific, if I go back to the structure.

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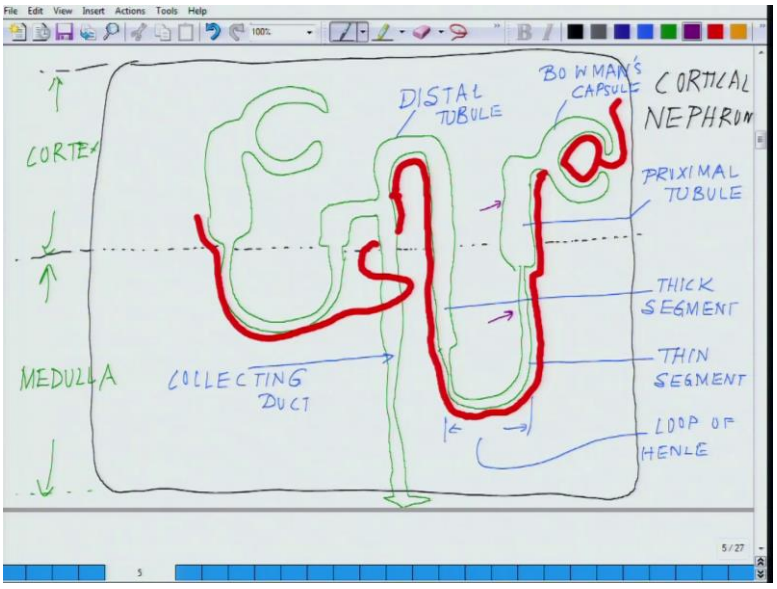

If we look at the structure, the blood vessels are, now I am just introducing the blood vessel. For your understanding, let me pick up the blood vessels. The blood vessels are like this, running like this, two tubes and the major junk of it is here, like this. We will come back in detail with all these things, how the blood vessels really are kind of, likewise. As I was showing you, in one of the previous slide, there are two parallel tubes side by side moving. This is how the complex it looks. That is why, I told you like, I will draw very simple diagram, which will make you understand that how they are. They are in side by side and there are specific zones. The way it is like, there are specific, fine.

There are specific zones where a specific kind of function is being taking place. There is something called counter current mechanism. There is all the possible diffusion and moment of solute is taking place; diffusion osmosis; counter current mechanism and everything. As long as this basic structure is cleared, it is fairly easy to understand the rest, but if there is a problem in the basic structure, then you will have problem in understanding, how this whole filtration assembly is functioning. Now, after that, let us summarize what all, we have done as of now.

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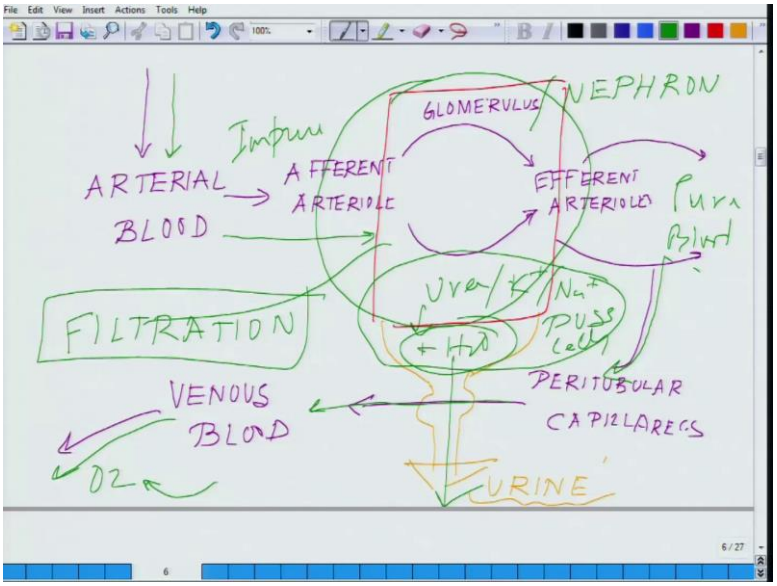

This arterial blood coming in, into the kidney and through the afferent arteriole; the one which is bringing the blood. Afferent arteriole moves into the glomerulus structure, which is basically, the nephronal structure. Then from there, it moves onto the efferent arterioles and this exchange is essentially, is taking place. This is this is the part, this is

the zone where I was showing you inside the Bowman's capsule, where this is all entering.

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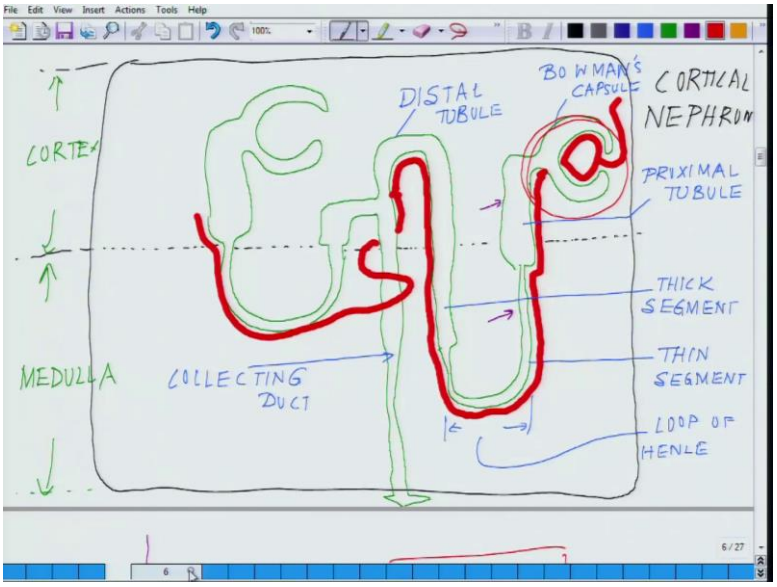

This is that zone, where this exchange is taking place. From here, it moves onto the very tubular capillaries. From there, it moves onto the venous blood. So, this is the whole schematics of the way, the blood is getting purified. This is the zone from here, whenever, whatsoever, the urine is being formed out here, is being eventually drained out in the form of urine. This is how it works, and this is the whole urine formation mechanism.

Again, to summarize it, you have arterial blood coming in through the afferent arterioles, moving into the glomerulus or the nephronal network. In the nephronal network, whole filtration is taking place, where the filtration takes place along with some of the water molecules; it has to be conserved, you mind it. All the other like urea, and all those things and few others, which are not needed; some of the electrolytes, and it moves down along with some of the puss cells and everything, in the form of urine, whereas, the pure blood from here. Here, you have the pure blood. Here, you have the impure ones. This pure blood, through the ferry tubular capillaries, moves to the venous blood and then it moves on. Then, it goes to the heart and they are basically, the oxygen, is taken from the lungs and again, it circulates all over the body.

So, this is the overall geometry by which, this whole thing works. What we will be doing next is, after this, we will come back and we will talk about, how the exact filtration assembly is taking place. So, I will close in here. So, in the next class we will talk about the exact mechanism by filtration is taking place, and what are the different control mechanisms.

Thank you.